Fabrication Techniques for Mems-based Sensors: Clinical Perspective

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Lecture - 19
Process flow for Fabrication of Interdigited Electrodes

Welcome to this module and this module is in continuation with our last module on which we were looking at fabricating a biochip, that is indicated with three different sensors and these three different sensors would be used to understand the change in the tissue properties. So, when I say change in the tissue properties, I mean a stiffness of tissue that is its mechanical property the resistance of the tissue, there is this electrical property and the thermal conductivity of tissue. So, we are looking at three different points mechanical, electrical and thermal.

In the last module what we have seen is that how we can fabricate a micro heater, on that how we can deposit a silicon dioxide and create a window and that process flow we have seen right. In this class, this module what we will look at? We will be concentrating on how we can further work on interdigited electrodes followed by other sensing layers. So, that finally, we have a biochip.

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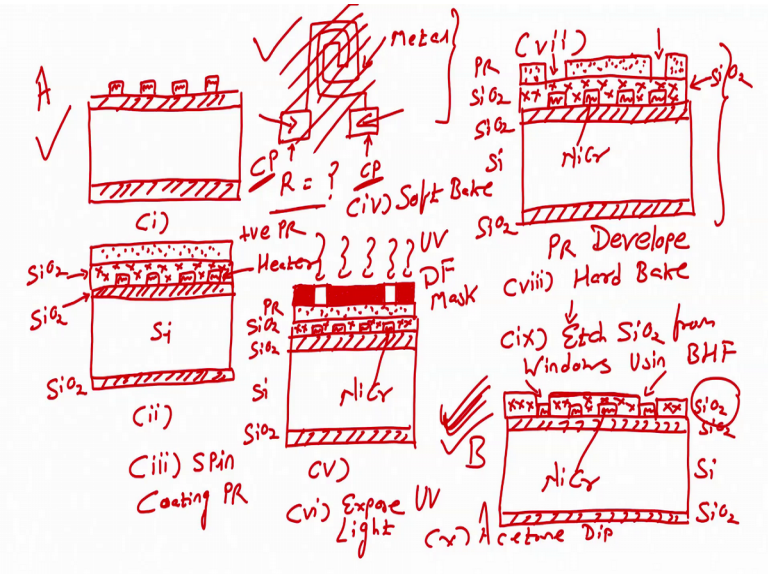

So, if you remember and if you see on the screen the last slide right of the last module was to show that we now have this particular one ok, this one my magnetics this one. So,

you have in micro heater on that there is a silica silicon dioxide which is an insulator and the contact area of the micro heater is opened; the contact area of the micro heater is open. You can see here contact area right the silicon dioxide is removed from this contact area. Now, what to do; now what to do? So, we will see now how to create an interdigited electrodes.

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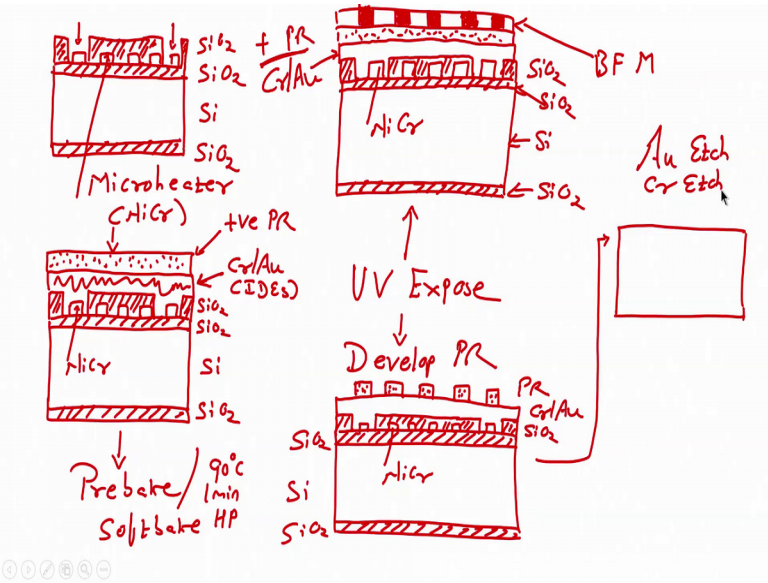

So, let me draw the last section of the last slide of the last module and that is I have a silicon wafer with silicon dioxide right, that is called oxidized silicon wafer ok. If there is a SiO 2 on silicon is called oxidized silicon wafer. On this oxidize silicon wafer I was having a micro heater; a micro heater like this and then this micro heater was protected by a insulating material right and this insulator is also silicon dioxide; this insulator is silicon dioxide. And you can see here the contact areas are opened; contact area is open silicon dioxide and this is your micro heater or we can say the material nichrome right.

What is the next step? Next step would be you take this oxidized silicon wafer, take the oxidized silicon wafer and on this oxidized silicon wafer where you have the micro heater, you have the micro heater correct and you have your contact area open right. On this I will deposit a metal which can be my chrome gold, this metal is will be used for patterning interdigited electrodes right. This is SiO 2, SiO 2 again because oxidized silicon wafer and this is my nichrome correct. So, we have a heater on which we had deposited chrome gold, chrome gold will be used for fabricating interdigited electrodes.

What is the next step? Next step we all know right. What is it? We have to spin coat, we have to spin coat of photoresist right, we have to spin coat a photoresist. So, this is my positive photoresist I have a spin coated it alright. Next step, next step will be soft baking or pre baking, soft baking or pre baking we know it is 90 degree centigrade of 1 minute on hot plate right.

After this next step would be, next step would be I will load I load my mask right, I have to load my mask. So, we have oxidized silicon substrate always this is your process flow guys, this is your process flow and we have heater 1, 2, 3, 4 lets draw it correctly; perfect 1, 2, 3, 4, 5 and then we have SiO 2 covering the heater right on that we have chrome gold on that we have photoresist.

Let me just draw a little bit thinner silicon dioxide. So, that we have enough space on that we have chrome gold on that we have photoresist sorry about this we have photoresist right, result of photoresist on that we have to load mask we had to load a mask. So, what should be my mask? My mask should be bright field mask, my brast would be bright field mask right because I want to save my chrome gold in this particular area to form my interdigited electrodes; to form my interdigited electrodes, all right this is what my bright field mask; bright field mask hm.

Let me write it down like this, bright field mask; what is this? This is my there is my photoresist right, photoresist which is soft bit positive photoresist then what is this one? This is my chrome gold right. What are these things? These are my silicon dioxide sorry, silicon dioxide and we know what is this? Nichrome, and what is this? Silicon dioxide, what is this one? Silicon, what is this one? Silicon dioxide correct, what is this? Bright field mask after soft bake we can load a bright field mask right.

Next is I will expose, I will use UV light to expose the above wafer when I perform UV exposure, what will happen? The area which is, the area which is the area which is not exposed; the area which is not exposed by UV light right will be stronger will be stronger, why? Because, we are using positive photoresist right. So, after UV expose I will develop this wafer in photoresist developer and develop this wafer in a photoresist developer. When I perform photoresist developing then after photoresist is developed what I will have, after photoresist is develop um. So, this is my photoresist then this is

my chrome gold, then this is my SiO 2, this is my nichrome right this is SiO 2 silicon SiO 2 correct, this what I will get after I perform my photolithography.

After this the next step is; the next step is that I will next step. So, I will just draw a line like this the next step would be I will etch; I will etch my chrome and gold right my metal to form interdigited electrode. So, how can I etch? I will dip this wafer in chrome etchant follow wind first gold etchant, gold etchant followed by chrome etchant; gold etchant followed by chrome etchant right. So, it is a wet etching process, wet etching process right. So, what will happen?

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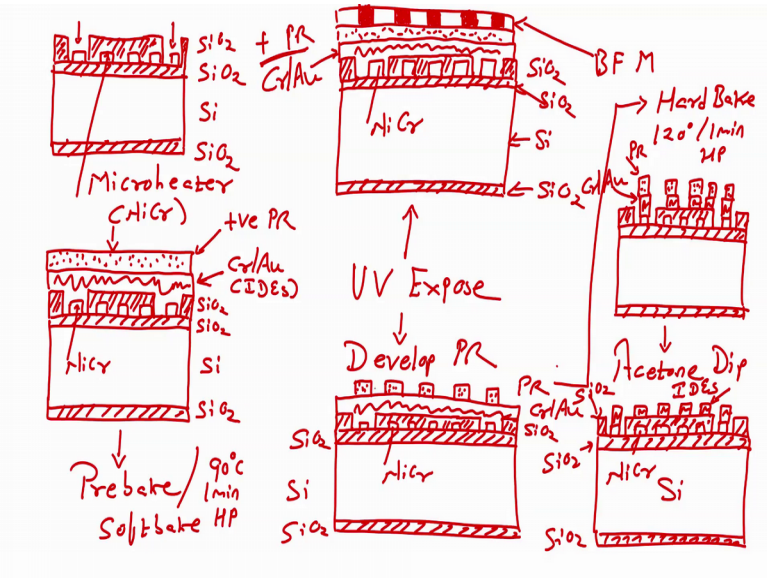

The photoresist will be stronger and it will stay as it is, the photoresist where it is protecting the chrome gold right will stay as it is. But see after you develop photoresist one step we forgot one step after developing photoresist, after developing photoresist the next step can be, our next step should be hard bake right hard bake. And hard bake is done it 120 degree 1 minute on hot plate alright, hard bake. Then we will do wet etching then we will remove chrome gold.

So, now when we remove chrome gold you should know, we should know that we have this heater on which there is a silicon dioxide right we have this heater covered by silicon dioxide and then when we perform this etching what we will see? We will see, what I think we are performing, performing wet etching wet etching wet chemical etching for removing chrome gold.

So, what is this? This is your photoresist right and this material right. So, how we are written chrome gold we have shown chrome gold by wavy line right we will draw wavy line everywhere so that we know what is chrome gold. So, here you see this is my wavy light chrome gold right and over chrome gold I have photoresist, this is my chrome gold.

Now, next step would be acetone dip, acetone dip. When I dip the wafer in acetone what will I have? I will have, I will have a beautiful oxidized silicon wafer on which there is a micro heater, there is a micro heater let us draw micro heater on which there are interdigited electrodes. These are interdigited electrodes right and this is your silicon dioxide as you know now.

So, what we have now, what we have? We have silicon, we have silicon dioxide, we have silicon dioxide once again for here right this is a protective silicon dioxide. Then we have here nichrome which is your micro heater and on the top of nichrome we have interdigited electrodes made up of chrome and gold, got it.

So, if we repeat quickly what is that you take this wafer where there is a micro heater and the context the migrator are open on that you deposit chrome gold followed by spin coating photoresist, which is a positive photoresist followed by soft bake which is done in 90 degree 1 minute followed by loading the mask and UV exposure then you have a bright field mass. So, the unexposed area because as, the positive photoresist will be stronger when the exposed area would be weaker.

So, after UV exposure you can see that the area which were, not exposed got stronger and this is the pattern that you get. After this you have to perform a hard bake which is a 120 degree 1 minute followed by etching the chrome and gold. First we have to dip in gold etchant followed by rinsing the wafer, rinsing is in using the DI and then you have to dip the wafer in the chrome etchant and again you have to perform a rinse DI rinse after that you have to put this wafer in acetone to strip off the photoresist. We do not require photoresist, when you strip of the photoresist with the help of acetone you obtain a wafer which has now a bottom layer which is a micro heater on this there is an insulator, on which there is an interdigited electrodes.

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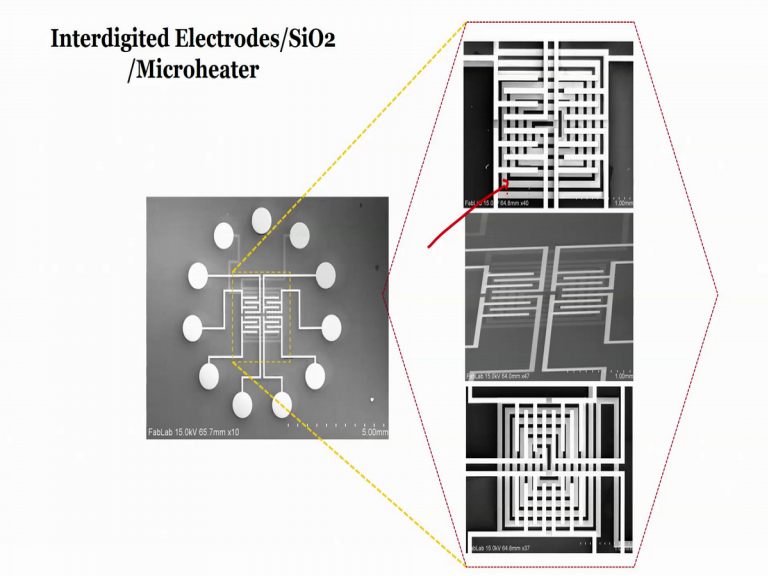

And this layer looks like the one that you can see in front of your screen right. What is this? There is a micro heater at the bottom if you see this one right, there is a micro heater at the bottom and then on that micro heater there is an insulator which of course, you cannot see because silicon dioxide transparent material. This is an SEM image right.

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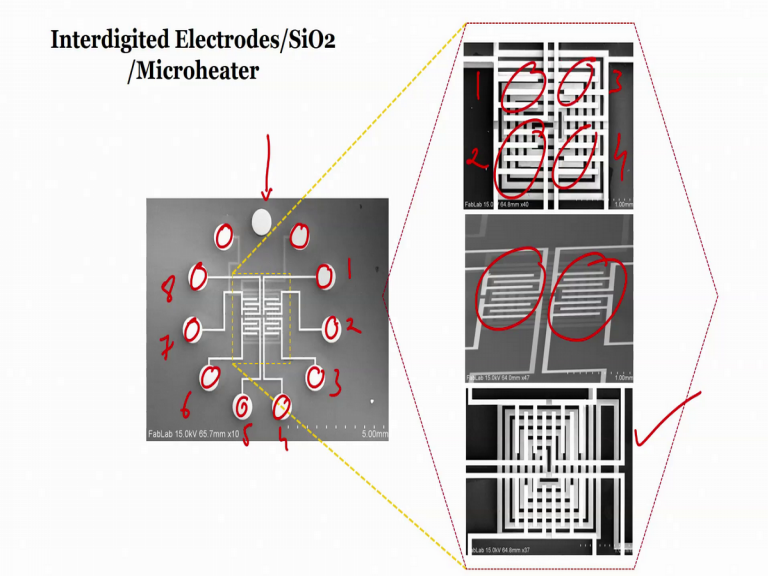

So, the bottom if you see these are the contact with a micro heater; these are the contact with the micro heater and then there is an insulator on which there are interdigited electrodes and you can see here that there are 1, 2, 3 and 4 right; 1, 2, 3 and 4. Four

interdigited electrodes that is why we need 8 contexts 1, 2, 3, 4, 5, 6, 7 and 8 and you can see there is one more gold electrode that we will see that why we are using that electrode.

But until here it should be completely clear to you what we have done, you can see this image as well where you can see a micro heater at the bottom right in the coil structure rectangular coil or rectangular fashion. On which there is an insulator, on which there is there are interdigited electrodes these are interdigited electrodes right 1, 2, 3, 4 correct. So, this is where we obtain our interdigited al electrodes. Now, the next step would be; the next step would be how to deposit an pattern piezo resistive material right.

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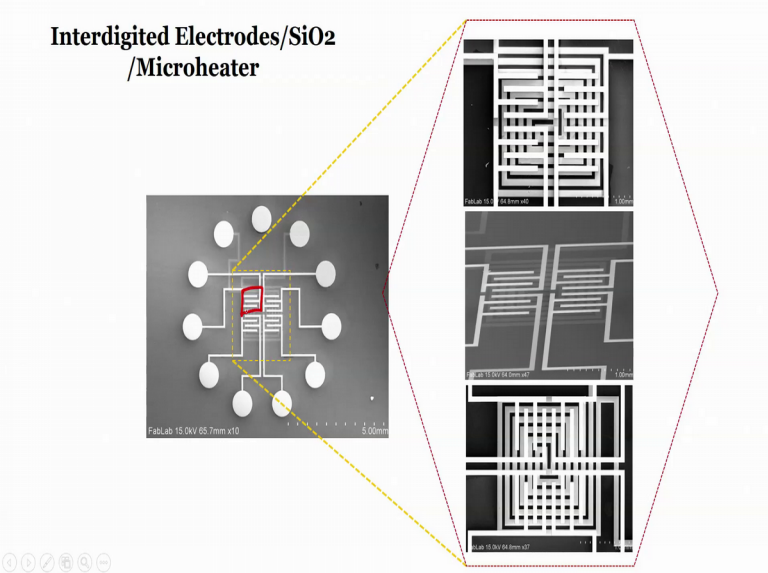

On this we require a piezo resistive material because our ultimate goal is to use this as a sensor to measure the stiffness of the tissue right, how to deposit piezo resistive material and then how to perform a photo lithography so that we can obtain a sensor, a biochip a biochip with a heater and a piezo resistive material right.

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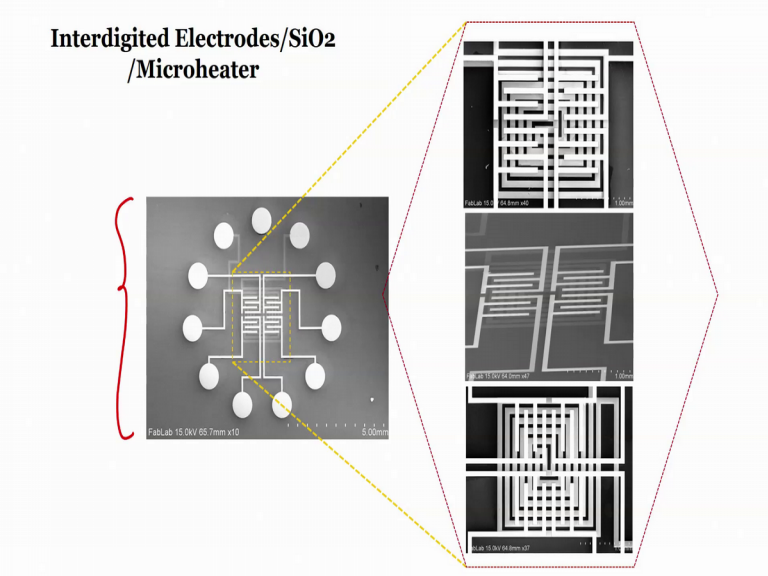

So, we will see the lithography technique in the next module where we will deposit a piezo resistive material on this particular wafer and then once we deposit using a PVD which is Physical Wafer Deposition peizoresistive material then we will perform a lithography. After that we have to perform a third step which is your insulator on piezo resistor on which there is an gold pad which will etch the electrical sensor and on that gold pad again we are using SU-8 pillars which will make it conductive.

So, if you see it is it looks very easy when you say that biochip indicated with mechanical sensors electrical sensors and thermal sensors, but when you fabricate it, it has multiple steps multiple steps. But again once you know photolithography or once you know the process flow and a recipe you can create many complicated devices and one such device we are talking about in this particular series of modules all right.

In the next module we will see how we can finish the biochip fabrication, till then you just look at the today's lecture. Look at what we have discussed see how we can obtain interdigited electrodes, what are the methods that I have talked which is particularly a lithography technique right.

Till then you take care, I will see you in next module bye.